Spallation Mix --- Bridging the Intellectual Gap

Kinetic Physics in ICF 2016 Workshop

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Outline of Talk

- Description of the "intellectual gap" that must be bridged.
- Summary of the kinetic physics not in current codes.
- Impact of including this missing physics in the codes.
- Summary

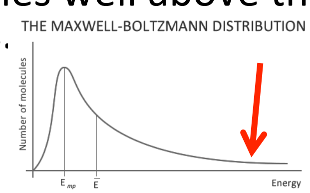
The Intellectual Gap to be bridged

- Current ICF simulations assume that (1) a few-Mbar shock turns solid ablator material into a plasma in a few picoseconds (ps), and (2) physics below a few eV can be ignored in target design as “chemistry.”

- Both statements are typically <u>not true</u> according to a great deal of theory, experimental data, and simulations outside of ICF.
  - A solid does not change phase in ps when there are <u>collective effects</u> involved, and kinetic physics below a few eV is not chemistry and should not be ignored.

- During a change in phase, most solids are subject to collective effects due to “lattice” configurations that must be eliminated before the solid will change phase — the phase change must “nucleate.” Without “defects,” it is “homogeneous nucleation.”

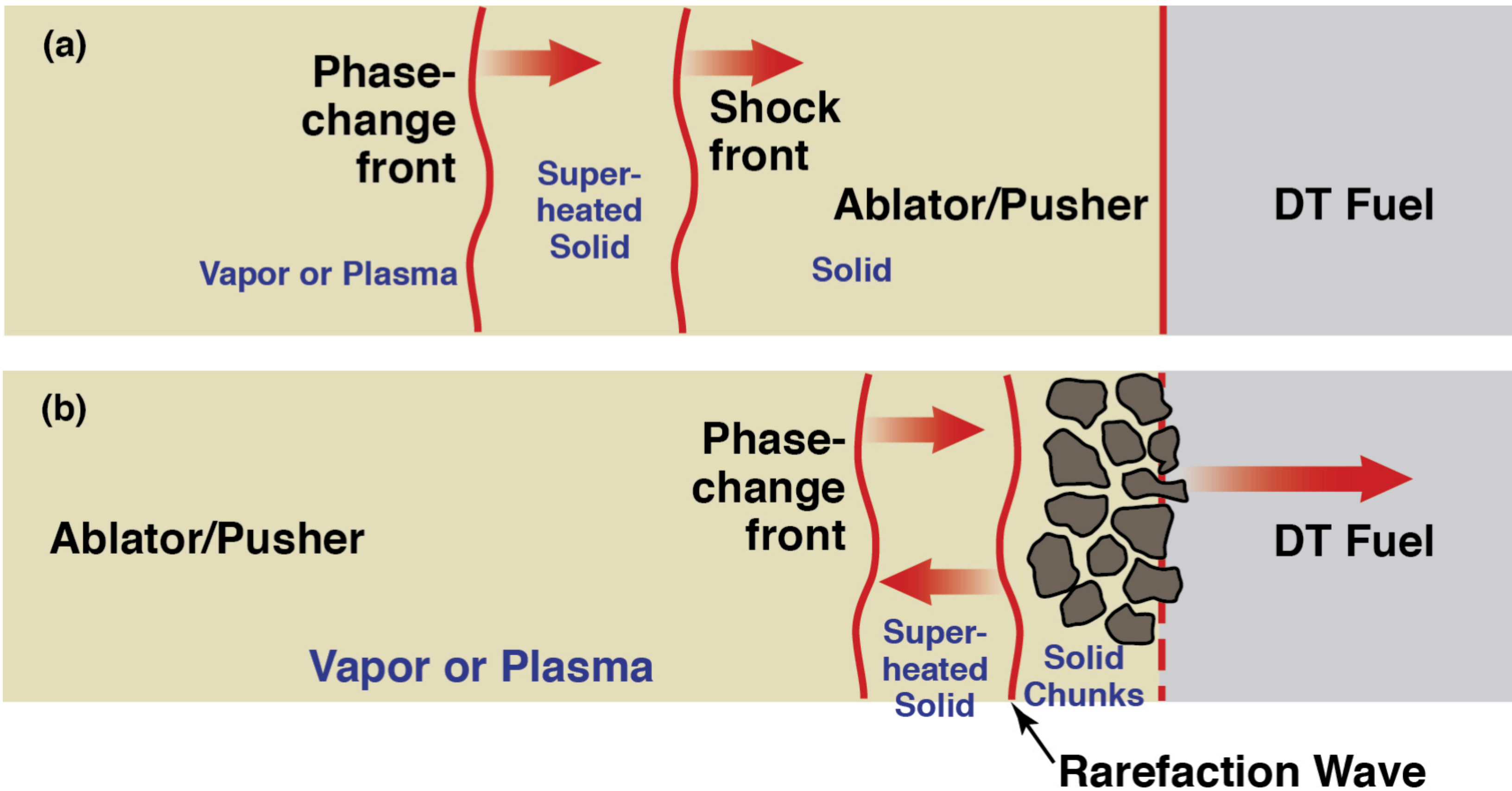
- Nucleation of a phase change to eliminate the solid-state “lattice” generally requires hundreds of ps or more for Mbar-level shocks because it is ions in the high-energy tail of the Maxwell distribution that disrupts these structures, and ion energies well above the mean ion energy occur only after orders of magnitude more collisions.



So, more time is required to complete the phase change.

- Such “homogeneous nucleation of phase changes” is not in current codes, and is <u>essential</u> kinetic physics that causes a significant observable time delay to complete a phase change.

Impact of including homogeneous nucleation is spallation of solid ablator chunks into the fuel



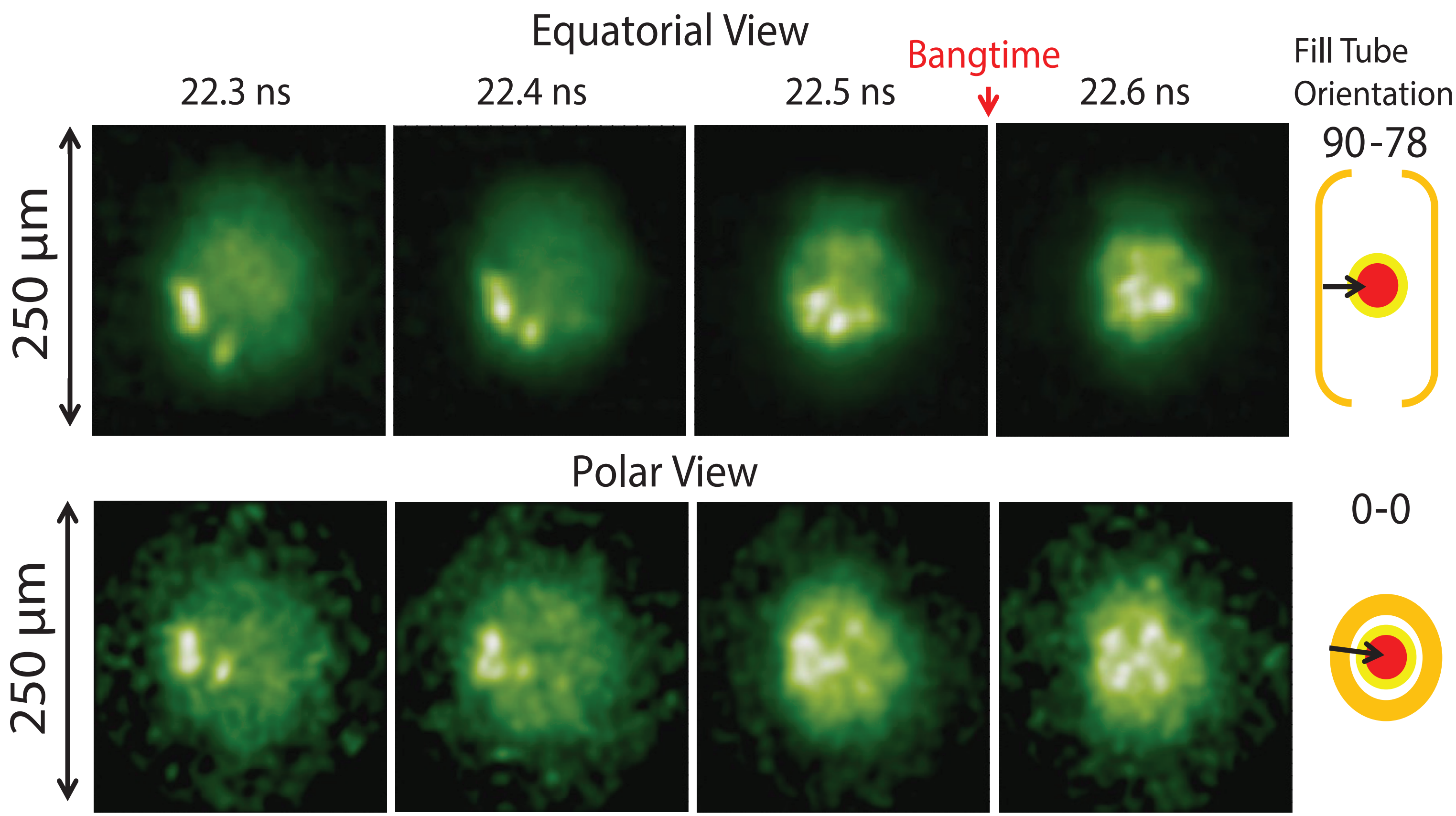
The departing chunks leave the DT interface roughened, seeding RT instabilities upon later pusher deceleration, which may affect diagnostic X-ray signatures.

Where can we find the published details?

For details relating to homogeneous nucleation of phase changes and spallation, as well as the propagation of spalled chunks through DT, see my publication that was published online 02/23/2016:

Charles D. Orth, "Spallation as a dominant source of pusher-fuel and hot-spot mix in inertial confinement fusion capsules," Phys. Plasmas, **23**, 022706 (2016).

Impact on NIC shot N120321 — Orth simulation predicts chunks in the hot spot, as for N130315



This is Fig. 14 of D. T. Casey, et al., Phys. Plasmas **21**, 092705 (2014).
N120321 yield was (clean 1D)/125: Clark, et al., Phys. Plasmas, **22**, 022703 (2015).

Summary

- Spallation produces chunks that may now have been seen in a hot spot. Spallation also produces the required amount of mix mass.
  - The Spallation-Mix model fits essentially all experimental data so far modeled by Orth, with no admixture of RT instabilities except for possible diagnostic X-ray signatures. Not one fusion yield has been measured higher than simulated in 1D by spallation mix and statistics alone.
- Nucleation of phase changes and spallation physics are well-documented in the literature, and are well-known outside ICF.
- We need to "bridge the intellectual gap" and put phase nucleation and spallation physics into our codes. It will make a BIG difference.

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